Agricultural Economics & Economics Dept.

College of Agriculture
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THE IMPACT OF WHEAT AND BARLEY ON
MONTANA COMMUNITIES

by

Gary W. Brester, M. D. Faminow and Bruce L. Benson

A Report Prepared Under Contract for the
Montana Wheat Research and
Marketing Committee

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Montana State University, Bozeman

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Chapter 1: Introduction

The Montana Wheat Research and Marketing Committee provided funding for a two-stage economic research project intended to first estimate the total impact of wheat and barley production on the Montana economy and then to disaggregate this total impact among the communities of the state. The first stage of the project was completed over the July 1983 - June 1984 period. An input-output model of the state's economy was developed and used to estimate the statewide impacts of wheat and barley sectors on other sectors of the Montana economy.[1] The second stage of this research project has now been completed. This report details the theory and methodology employed to dissaggregate the statewide impacts from the previous report and provides estimates of those impacts on three types of communities.

Details on the Montana input-output model (MIOM) and its predictions of statewide impacts of wheat and barley are not provided here. Interested readers should see our earlier research report.[2] This report concerns itself only with the dissaggregation of those statewide impacts. Thus, it is divided into four chapters in addition to this introduction.

Chapter 2 develops the relevant theory for understanding and estimating the linkages between the agricultural sector and the urban centers of the state. The theory (referred to as Central Place Theory) makes it clear that even the largest city in an agricultural region is impacted by changes which occur for the rural population. The model describes a hierarchical system of cities and trading areas where the smallest communities provide goods and services to the rural population in their immediate vicinity, while larger communities provide these same goods and services to the immediate rural population plus additional goods and services to more distant rural

populations and residents of smaller communities. Bigger cities have larger trading areas and provide more goods and services, but in a purely agricultural region the well-being of urban residents is directly linked to the well-being of the rural population.

Chapter 3 describes the methodology employed to classify Montana communities in a central place hierarchy. Cluster analysis was employed to group cities on the basis of income into three hierarchical levels. Furthermore, the eastern portion of the state is primarily an agriculturally based central place system (it produces virtually all the state's wheat and barley, for instance) while the western part of the state's central place system is more oriented toward lumber and tourist industries. Therefore, the state is separated so that the region dominated by agriculture can be emphasized in the estimation process.

Chapter 4 details the estimates of the impact of wheat and barley on typical (or average) cities in each of the three levels of the hierarchy for both the eastern and western regions of the state. As predicted in the theoretical section (chapter 2) the largest cities in the state actually feel the largest impact in an absolute sense when something happens to the wheat and barley sectors. However, in a relative sense, the smallest cities are more significantly impacted. If wheat production falls, for instance, more jobs will be lost in Great Falls and Billings (from hierarchy one -- see chapter 3) than in Havre and Glasgow (hierarchy two), or in Chester and Malta (hierarchy three), but a larger portion of Chester and Malta's total jobs will be lost than Glasgow and Havre's, or than Great Falls and Billings'. At any rate, the impact of the wheat and barley sectors on every community in Eastern Montana is substantial.

Chapter 5 provides a brief summary of the two-year project.

Notes

1. For details, see Gary W. Brester, M.D. Faminow and Bruce L. Benson, *The Impact of Wheat and Barley on the Montana Economy: An Input-Output Approach*, Department of Agricultural Economics and Economics, Montana State University, June 1984.

2. *Ibid*.

Chapter 2:
A Hierarchy of Trading Areas:
The Theoretical Rationale

Within any region there is a network of cities and towns of varying sizes. This network and the sizes of various communities may appear to be a haphazard scattering of economic activity representing the outcomes of random events, but that is not the case. Very orderly networks of towns and trading areas develop as a consequence of economic forces - forces that produce different sized market areas for different goods and services traded in the region. These forces lead to the development of an interrelated hierarchy of towns and cities wherein occurrences in the region's smallest town (or in the rural area served by businesses in that smallest town) have repercussions in the region's largest city. The purpose of this chapter is to explain from a theoretical perspective how such a network arises, and the trade flows which occur within the hierarchy of cities and towns. In addition, a brief discussion of previous empirical studies of such hierarchical networks is provided.

The theoretical explanation of a network of cities is referred to as central place theory. This theory was first developed by Walter Christaller and August Lösch.[1] However, theoretical analysis in this area of research is ongoing, as it is an important issue for both economists and geographers interested in urban and rural problems and policies, and in the impact of transportation costs and networks on the location of economic activity.[2] An understanding of how and why a network of cities develops requires an understanding of how and why geographic trading areas develop for specific goods or commodities. Therefore, let us turn first to a consideration of these individual geographic trading areas.

Trading Areas for a Single Good

Imagine a homogeneous (featureless) plain occupied by self-sufficient farm families of identical tastes and living standards. These farm families are uniformly distributed over the plain on farms of identical size (e.g. homesteads). This hypothetical situation is developed in order to simplify the arguments which follow, but the same general conclusions derived here can be obtained from a much more realistic (but complex) geographic distribution of economic activity.

Now suppose one particular commodity consumed by these self-sufficient farm families can be produced at a lower cost per unit if it is produced in quantities larger than a single family consumes. Call that good milk. In other words, if one farmer were to specialize in the production of milk he could produce at a lower per unit cost than his neighbors and thereby sell milk to them at a price which is lower than the cost that the neighbors would have to incur to produce milk themselves. Therefore, suppose one farmer specializes in producing this dairy product and then trades milk with his neighbors for the commodities he no longer produces. The question is, how far will this dairy farmer ship his milk - that is, what will the farmer's geographic trading area look like?

The dairy farmer will have to charge a price (in the simple barter economy alluded to here that price would be in terms of other goods, but we shall assume that money is used so that the farmer sells milk for dollars and then buys other products from his neighbors). That price must be sufficient to cover his costs in terms of what he gives up producing, and therefore must buy, because he has specialized (presumably the seller will also expect a profit above costs or he would have no incentive to specialize). That cost will reflect both his production cost and the cost

of transporting the milk to his neighbors. Therefore, the further away a buyer is from the dairyman's location the higher the price that buyer must pay. Figure 2-1 reflects such a pricing schedule. The vertical axis of the graph is denominated in dollars to represent delivered price while the horizontal axis represents distance. The dairy farmer is located at point A. The price charged at his farm is P, but the price charged to customers as the milk is shipped from point A increases to reflect transport costs. The delivered price in Figure 1 consists of P plus the transport costs td, where t is the transport rate per unit of distance and d is units of distance.

Clearly, in this simple example, the dairy farmer's trading area will be limited. All farm families can produce milk, after all, even though their costs are higher than those of the dairy specialist. But as transportation costs are added to the price the dairy farmer charges, the delivered price rises toward the costs individual families would have to incur to produce milk themselves. No family is likely to buy the product for more than the cost of producing it themselves. Therefore, suppose that the per unit cost of producing milk for a non-specialist is at C in Figure 2-1. If the delivered price from A rises above C no sales will be made. A single firm's geographic sales area boundary occurs where buyers are indifferent between paying that price or not purchasing the product (at points a and b in Figure 2-1) - perhaps producing it themselves.

Figure 2-1 represents the sales area along a single line. In a featureless geographic plain with an even distribution of potential consumers that sales area would be a circle, as in Figure 2-2.

If it proves profitable for one farmer to specialize in dairy production it will prove profitable for others to do the same thing in other

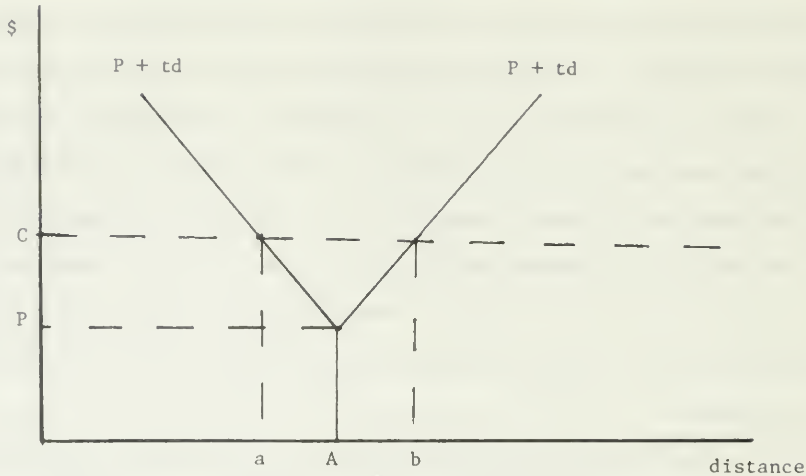


Figure 2-1: Trading area for a linear market.

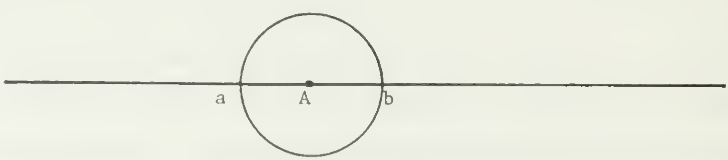


Figure 2-2: Trading area for a plain.

areas. As long as it is possible to do so, these specialists will try to avoid head to head competition with other dairies. Thus, circular trading areas will dot the landscape initially. At some point, however, as these circles begin to fill up the plain, competition between dairies will have to occur. Figures 2-3 and 2-4 represent the consequences of such competition for geographic trading areas. In these figures dairies A and D are assumed to be established and selling over their trading areas without facing any competition. Those trading areas are the distances ab and cd for sellers A and D respectively in Figure 2-3, and the circles centered on A and D in Figure 2-4.

Now let a new dairy, B, locate between the previously existing dairies. The maximum prices that buyers located between A and D will pay any one seller is no longer given by their own costs, but by the prices set by competing firms. That is, buyers will buy from the firm which offers the product at the lowest delivered price. Therefore, the trading area boundary between two firms is determined at the buyer location where that buyer is indifferent as to which seller he buys from - where the delivered price from the two firms are equal. This occurs at points e and f in Figure 2-3, so dairy A now sells over the trading area ae, while B sells between e and f, and D controls the area fd. When we visualize a plain, the boundary between firms' trading areas is a straight line as in Figure 2-4.

Now consider what happens as dairies are established which compete for trading areas with A, on all sides of A's trading area. A's circular trading area is transformed into a multi-sided shape with straight line boundaries between A and his rivals, as in Figure 2-5. Figure 2-5 depicts A's trading area as a hexagon shape, with rival firms at points B, V, W, X, Y and Z also having trading areas of identical size and shape due to

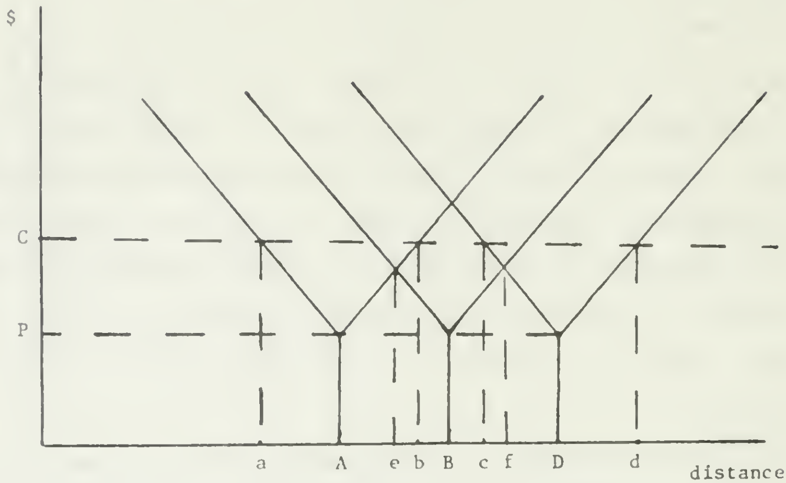


Figure 2-3: Trading areas with competition from a distant seller.

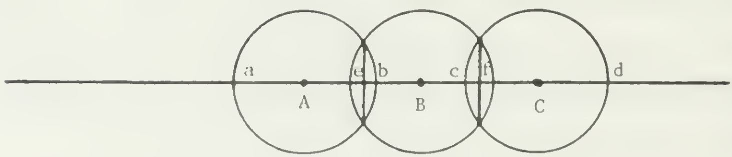


Figure 2-4: Trading areas in a plain with distant competition.

competition from A, each other, and even more distant (from A) competitors (e.g. D). This honeycomb pattern of trading areas has been shown to arise under the circumstances assumed here. In particular, we have assumed a homogeneous plain with identical buyers evenly distributed over the plain. As a result sellers who face identical production and transportation costs will also end up being evenly distributed over the plain although the distribution will be more sparsely populated than that of the consumers. A complex mathematical proof could be provided, but it seems unnecessary. Intuitively, this honeycomb pattern is the one that will fill the entire space so all consumers are served, and minimize total transportation costs. Squares, or triangles would also fill the entire space but a firm serving the same number of consumers in one of these trading area shapes as in a hexagon will have to ship greater total distances. The forces of competition and the profit motive will ultimately generate a minimization of transportation costs, thus producing hexagon shaped trading spaces.

In a sense, this may appear to be irrelevant. After all, the assumptions of evenly distributed identical consumers over a featureless plain do not describe very many real world landscapes or markets, if any. However, the pattern depicted here is very useful in illustrating that <u>a system of large cities and towns of unequal size will arise even in the absence of considerations of economic forces we might expect to be the cause of such a pattern</u> - forces like the uneven distribution of consumers, or locations with comparative cost advantages due to the existence of favorable resource endowments, topography, soil, and so on. Therefore, let us turn to the development of a system of cities and towns in this hypothetical environment.

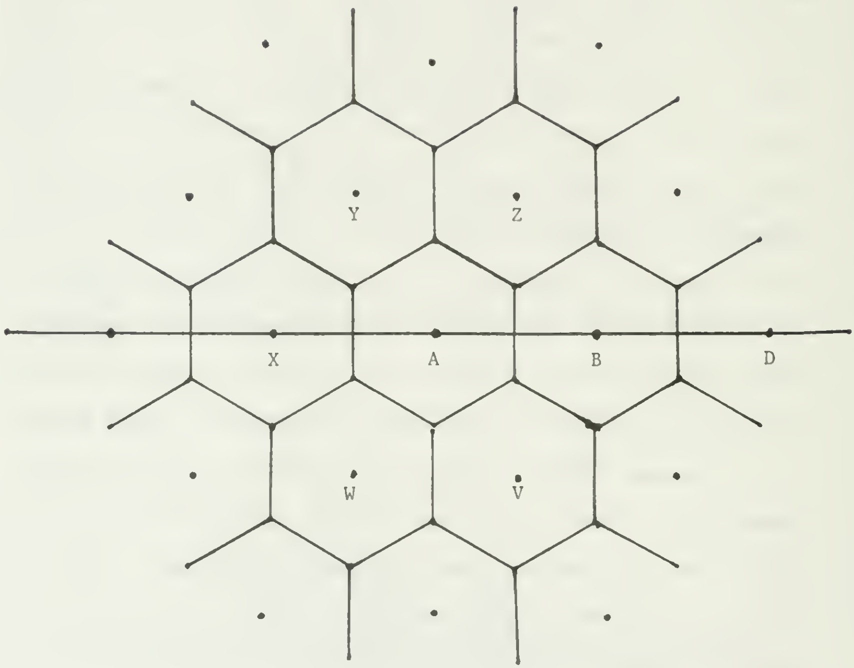


Figure 2-5: Trading areas in a competitive equilibrium.

A Hierarchy of Central Places and Trading Areas

Consider what happens when a second area of specialized production (in addition to milk) arises. There are many reasons to expect that this second specialist will be attracted to a location in the vicinity of a specialized production site for the previously existing industry. For instance, the new specialist may use milk as an input (e.g. a candy maker, a cheese factory) so in order to minimize the transportation cost of that input he locates next to a dairy. Or the new specialist may produce an input for the existing industry and to minimize the cost of delivering the input the new specialist locates next to a firm from the existing industry (e.g. maybe someone specializes in the production of feed for dairy cattle, or of milk bottles). These obvious links between firms in different industries are not necessary however. Existing locations may be attractive to entrants in a new industry for other reasons as well. For instance, perhaps the milk producers have established a network of routes (roads, wagon trails) for delivery of their product. The new specialist producer may want to deliver to many of the same customers and could, by locating near an existing milk producer, use the existing transportation network.

A little more up-to-date example occurs in retailing. If spatially distributed farm families buy food, clothing, shoes, farm equipment, seed and so on from different retailers, it pays for many of these retailers to cluster together in one retailing center (a town). A clothing store located near a food store, shoe store, and/or implement dealer, etc. is much more attractive to a buyer than a clothing store located off by itself, because the farm family can minimize its total transportation (and search) costs arising from shopping by going to one location to buy from several stores rather than to several dispersed stores. Therefore, very different kinds of

retail outlets tend to locate together even though they may have no direct dealings with each other.

The discussion in the preceding paragraph should indicate why towns develop. As more and more individuals specialize in different production processes there is a strong tendency for them to cluster together and form communities. But the above discussion does not indicate why different sized communities might develop. Why are cities not all identical? The primary reason is that different types of specialized firms will sell over different sized trading areas. There are several reasons for this to occur. For instance, the transportation costs per unit of distance certainly differs from product to product. Large, heavy products or perishable products cost more to ship than light non-perishable products. The higher the transport rate, the smaller the trading area, all else equal.

Another factor in determining the size of trading areas is consumers' willingness to buy. Consumers, in our hypothetical setting may be willing to pay much more for one good than for another because it costs them much more to produce the first themselves than it does the second. Furthermore, the first may be much more valuable to them in that they get much greater satisfaction from consuming it. The more consumers are willing to pay for a particular quantity the greater the potential trading area, all else the same.

One of the most important determinants of trading area size is what is referred to as economies of scale. A specialist can generally produce a good at a lower per unit cost than a non-specialist because the specialist operates at a larger scale. One reason is that various costs of production are spread over a larger number of units of output so the average cost falls. In addition, in some industries, firms which operate at a large

scale are able to take advantage of various technologies that a small producer cannot afford to adopt, since the technologies involve specialized capital or labor. Adam Smith, the father of the science of economics described the consequence of specialization and division of labor with the following very revealing example:

> To take an example, therefore, from a very trifling manufacture; but one in which the division of labour has been very often taken notice of, the trade of the pinmaker; a workman not educated to this business (which the division of labour has rendered a distinct trade), nor acquainted with the use of the machinery employed in it (to the invention of which the same division of labour has probably given occasion), could scarce, perhaps, with his utmost industry, make one pin in a day, and certainly could not make twenty. But in the way in which this business is now carried on, not only the whole work is peculiar to a trade, but it is divided into a number of branches, of which the greater part are likewise peculiar trades. One man draws out the wire, another straights it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving a head; to make the head requires three distinct operations; to put it on is a peculiar business, to whiten the head is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them. I have seen a small manufactory of this kind when ten men only were employed and where some of them consequently performed two or three distinct operations. But though they were very poor, and therefore but indifferently accommodated with the necessary machinery, they could, when they exerted themselves, make among them about twelve pounds of pins in a day. There are in a pound upwards of four thousand pins of middling size. Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day. Each person, therefore, making a tenth part of forty-eight thousand pins might be considered as making four thousand eight hundred pins in a day. But if they had all wrought separately and independently, and without any of them having been educated to this peculiar business, they could certainly not each of them have made twenty, perhaps not one pin in a day; that is, certainly, not the two hundred and fortieth, perhaps not the four thousand eight hundredth part of what they are at present capable of performing, in consequence of a proper division and combination of their different operations.
>
> In every other art and manufacture, the effects of the division of labour are similar to what they are in this very trifling one; though, in many of them, the labour can neither be so much subdivided, nor reduced to so great a simplicity of operation. The division of labour, however, so far as it can be

> introduced, occasions, in every art, a proportionable increase in the productive power of labour. The separation of different trades and employments from one another seems to have taken place in consequence of this advantage.[3]

Adam Smith published the book containing this example in 1776 but it still contains the essentials of the logical argument being made here. If labor in pin-making was worth, say $1/day, then a non-specialist would have produced pins at an average (or per unit) cost of 5¢ per pin, assuming 20 pins were produced. By specializing and hiring ten laborers for $1/day, the firm Smith described would have produced 48,000 pins at a cost of slightly over 0.02¢ per pin, assuming labor was the only input to production. Of course, there were also machines that the specialist used but even if the cost of machines was 1¢ per pin per day (or 3.5¢) the specialist produced at a lower per unit cost than the non-specialist. Thus, there were economies of scale. This is a primary reason for specialization.

The Smith quote also points out that the potential for specialization through division of labor varies from industry to industry. Some production processes allow a large specialized firm to produce at a substantially lower cost and therefore survive while charging a substantially lower price, than a small firm or a non-specialist. In other industries this is not the case. The more significant the cost differential between large and small producers the larger the trading area a large firm can serve, all else equal.

The interaction between production costs, transportation costs and consumer willingness to pay determines the sizes of trading areas for different specialized producers in the absence of distant competition. Figures 2-6 and 2-7 illustrate a hypothetical situation in which firm A (the milk producer) is located next to firm E, say a brewery. Assume the maximum price consumers will pay for beer is C' (as opposed to C for milk) but that economies of scale are considerably greater for a brewery than for a dairy

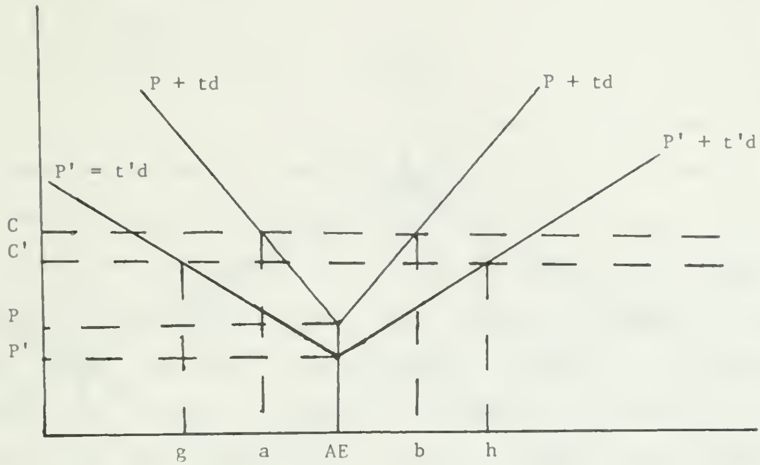


Figure 2-6: Trading areas for two different products.

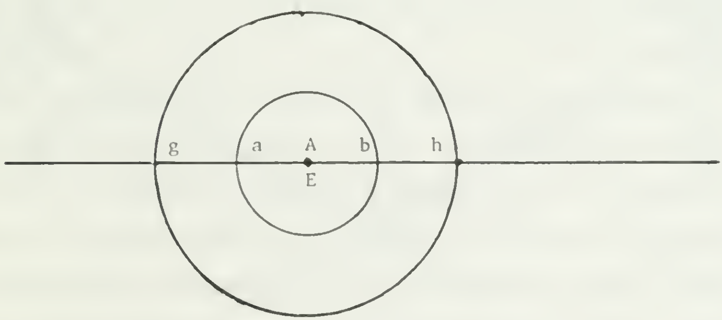


Figure 2-7: Trading areas on a plain for two different products.

so the brewery sets a price P', lower than the price of milk, P. Furthermore, assume that the transport rate per unit of distance for beer, t', is less than the rate for milk (beer does not have to be refrigerated to transport). The trading area for the brewery (gh), therefore, exceeds that of milk under the assumptions developed here.

Competitive entry at distant locations will shrink the brewery's trading areas as it did with the dairy industry. Conceivably, entry could ultimately generate trading areas for milk and beer of identical size. There certainly are many different types of firms in a community which have very similar trading areas, particularly in retailing. However, substantial differences in production cost relationships, transport costs and/or consumer demand will generate very different competitive trading area sizes for different industries. One brewery, for instance, may serve the same area and population that is served by several dairies, as in Figure 2-8, where each brewery serves the same area as four dairies (1 + (1/2)6). In this system the locations (communities) indicated by the double circles have both a dairy and a brewery while those with the single circles have only dairies.

Still other specialized functions will involve larger or smaller competitive trading areas. Figure 2-8 includes a system of four different sized central places (cities and towns). The largest, with three circles in Figure 2-8, produces all the goods and services offered in this region and provides some services to every family inside the large hexagon. The smallest, those represented by a dot, serve consumers located inside the smallest hexagons. Notice that all the communities in the second level of the hierarchy provide the goods and/or services provided by the smallest towns plus some additional services. If a resident of the smallest

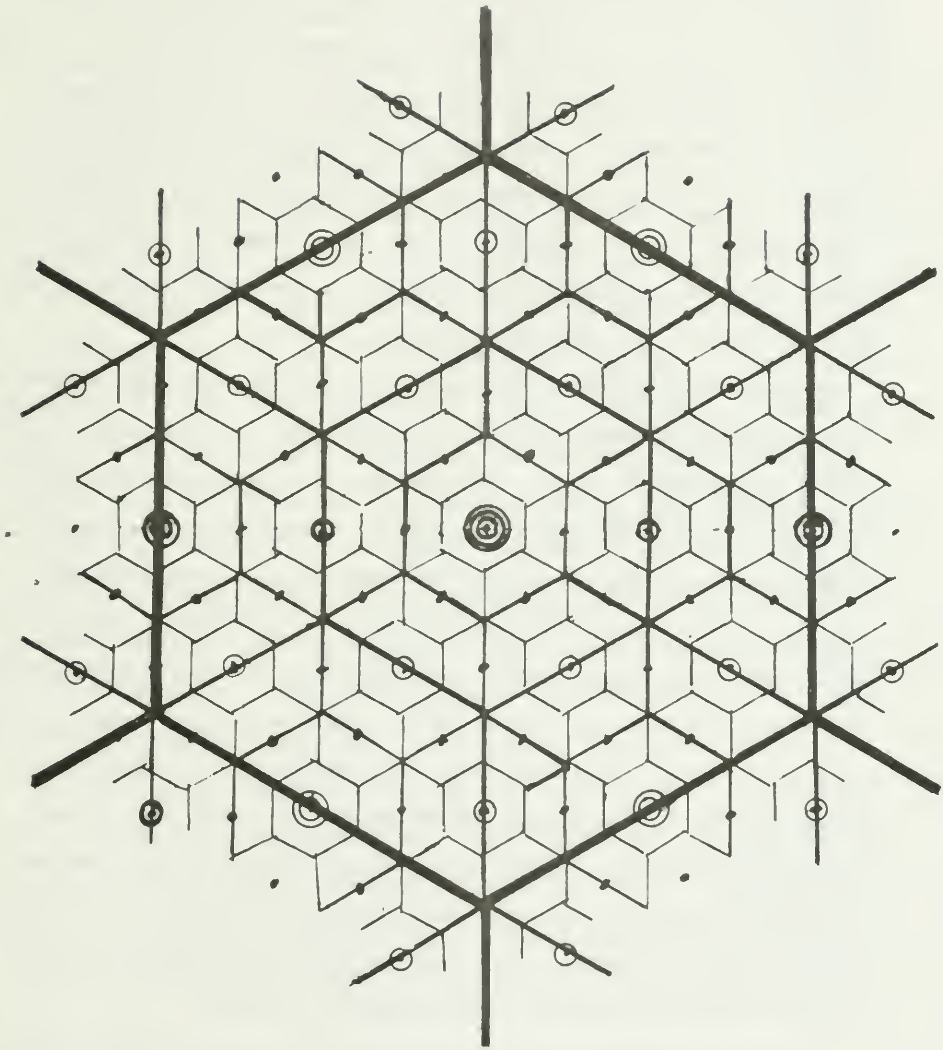


Figure 2-8: Trading areas for different products in competitive equilibria.

communities or a rural resident served by one of the smallest towns wants to buy some of the second level goods or services (e.g. milk in the hypothetical development above) they must get it from one of the second (or third or fourth) level towns. All the third level communities produce every good and service available in the second level communities, including everything produced in the smallest towns, plus even more goods and services (e.g. a brewery in the preceding arguments). The largest city in the region produces every good and service available in every other community in the region plus additional goods and services not available in any other third or second level towns or in the smallest communities.

Now, what happens to a theoretical central place hierarchy when we move to a real world setting? Certainly the geographic characteristics of the hierarchy may change, but the important economic characteristics do not. Consider a few possibilities. Suppose that instead of the transport system arising as the central place structure develops, the transport system, or at least certain aspects of it, are in place first. In Montana, rivers provided early traders and trappers with their best means of travel. Therefore, many of the earliest trading centers (central places) were established on rivers (e.g. Fort Benton, Miles City, Missoula). Similarly, trail heads (Bozeman, Miles City) had transportation related advantages. As a central place hierarchy arose, these locations with natural transportation advantages obviously became focal points around which the rest of hierarchy tended to develop. However, Montana really did not develop an extensive system of cities and towns until the railroads entered the states.

Consider the development of towns along the original Great Northern route. Initially, communities sprang up approximately every ten to fifteen miles apart along the route. These communities served the homesteader

population that moved in to the state on the railroad. But they did not all develop at the same rate. Roughly every other town developed more quickly than those in between. Moving east from Havre, for example, we find Lohman, Chinook, Zurich, Harlem and so on. Havre, Chinook and Harlem developed much more rapidly and to a much greater extent than Lohman and Zurich. Why? Probably because the Great Northern Railroad chose to make Havre a major repair and switching point so the central place structure that evolved along the railroad centered on Havre. Transport costs of agricultural commodities to the railroad and consumer goods back to the farms dictated, in the early development of the area, that a community exist every 10 to 15 miles along the line. However, as transportation technology advanced (from horses and wagons to trucks and cars, to bigger and faster trucks and cars) farm families could travel further to trade at relatively large communities where more goods and services were available. That meant that Havre, with its natural size advantage arising from providing goods and services to the railroad workers as well as the rural population, would attract consumers from the Lohman area. Every other town developed, so Chinook grew, Zurich did not, Harlem did, and so on.

Naturally, as some towns grew more than others, they became the most attractive locations for other central place functions established by both the private sector and by Government. Havre was a natural choice as a Hill county seat and ultimately for Northern Montana College, for instance, and obviously Chinook or Harlem would be chosen over Zurich as county seat for Blaine county.

As motor transportation developed the relative importance of the railroad declined, but the highway was generally built along the railroad route, so the basic hierarchy that developed because of the railroad has not

changed too much. Today we see, along Highway 2 east of Havre, a series with every other town being very small, virtually ghost towns, while those in between maintain populations of roughly a thousand to perhaps three thousand, until we reach Glasgow. Havre and Glasgow are clearly cities with similar central place functions. Chinook, Harlem (with Fort Belknap), Malta, and others are also similar. Zurich, Lohman, and the other smaller communities are disappearing now and provide only very minor central place functions.

The point is that the transport system both shapes (e.g. rivers, railroads, the advent of motor vehicles) and is shaped by (e.g. highways) the central place system. Other factors influence the system as well. Topography and soil conditions vary, for instance, so some parts of a region may support relatively small farm populations and therefore relatively small communities, while others support larger populations and communities. Furthermore, many communities produce goods or services that are not part of the basic central place functions. In Montana, for instance, many communities sprang up to serve gold miners. Most of these towns disappeared because they had no non-mining population to serve so when the miners left the towns died. But some (e.g. Butte, Helena) survived. They did so largely because they continued to produce minerals like copper or mineral related goods or services (e.g. smelting) for export after the gold mining disappeared. In addition, however, they lasted long enough to develop central place functions in addition to their extractive and exporting functions. They have become part of the central place system in Montana, just as some of the earliest trading centers with transportation advantages did, because as new transport systems developed (mainly highways) they were already in existence and were connected into the network.

The communities which end up being the largest cities in a central place hierarchy may do so because they have some non-central place functions as well which provide them with basic employment that must be served (like Great Falls, first with its smelter and then with its Air Force base). As a service sector arises to serve both the local employment and to provide central place functions for nearby rural populations, the size of such towns made them attractive for those central place activities which require larger trading areas. It is not surprising, then, that Billings and Great Falls provide major (for the state) daily newspapers to much of the eastern Montana region, but that Havre, Bozeman and other smaller cities' daily papers are smaller and more localized, and towns like Harlem and Chinook have very small weekly papers with almost completely local circulation.

Many economic factors influence, and even distort the central place hierarchy then. Some cities may be larger than their central place function would warrant, because they produce other things as well. Are these distortions severe enough so that it is inappropriate to view a system of cities and towns as a central place network? A number of studies indicate that, particularly in agricultural regions, the central place model describes the system of urban areas very well. A brief discussion of a couple of relevant central place studies follows.

Empirical Studies of Central Place Hierarchies

One of the best known central place applications was August Lösch's study of Iowa. Lösch used 1930 census data and tested a model precisely like the one depicted in Figure 2-8, except that he considered a six level hierarchy instead of the four pictured in the Figure. The smallest size class city consisted of those towns with populations of 180 to 1000. There

were 615 such communities in Iowa in 1930. From this, Lösch was able to predict the relative size of larger central places and the number of each size of city which should exist in the state.[5] Furthermore, given the size and geometry of the state Lösch was able to compute the theoretical distances separating cities in the same size class. Table 2-1 contains Lösch's theoretical predictions and the actual numbers which arose in 1930 Iowa. Notice how closely the actual size distribution and location fits with the predicted results. Given the number of things which might distort a system of cities away from the pure central place hierarchy, Lösch's results seem quite amazing. Of course, Iowa may fit the assumptions of the central place model (homogeneous plain, even rural population distribution, etc.) as well as any place in the world, but many other studies have looked at larger less homogeneous regions, with similar results.

The best known modern application of central place theory in the United States is a study of the upper Midwest done by economists and geographers from the University of Minnesota in the early 1960s.[6] This very extensive and costly study classified over 2200 trading centers in the 9th Federal Reserve District, consisting of Montana, North Dakota, South Dakota, Minnesota, northwestern Wisconsin and upper Michigan. Communities were classified into eight size ranks in the central place hierarchy. Figure 2-9 identifies the major production and service activities found in the six largest size classes of relevance to Montana (Minneapolis-St. Paul was in a larger size class by itself). The central place model developed by Christaller predicts that a city will provide all the goods and services available in all smaller sized towns plus some more. This prediction is borne out for the upper Midwest region of the early 1960s. It should be noted that in this study Great Falls and Billings were classified as

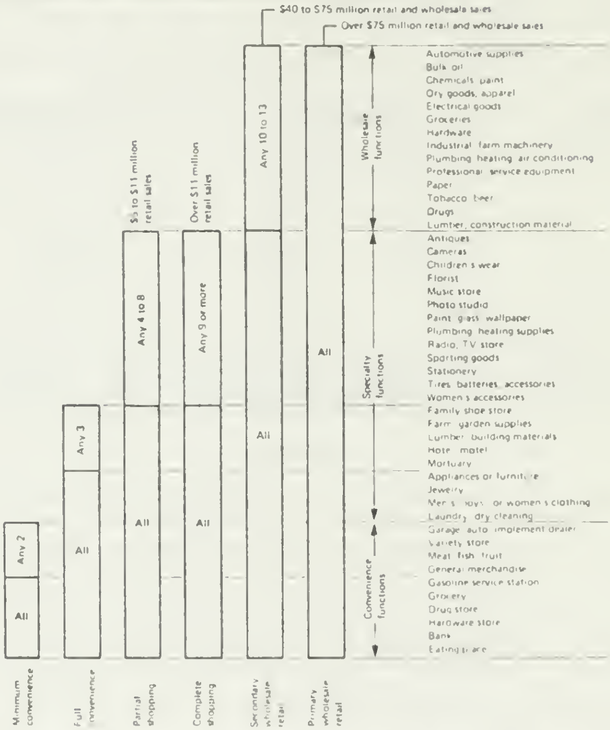
Table 2-1

Results of Lösch's Study of Central Places in Iowa.

Size-class central of place trading areas	Central Places			
	Number		Distance Apart	
	Theory	Reality	Theory	Reality
1	615		5.6	
2	154	153	11.2	10.3
3	39	39	22.4	23.6
4	10	9	44.8	49.6
5	2-3	3	89.6	94.0
6	0-1	0	--	--

Source: August Lösch, The Economics of Location, trans. William H. Woglam (New Haven, Conn.: Yale University Press, 1954), p. 435.

FIGURE 2–9
Goods traded in cities at different levels in the hierarchy



Source John R Borchert, "The Urbanization of the Upper Midwest," Upper Midwest Economic Study, Urban Report No. 2 (Minneapolis, February 1963), Figure 4, p. 12

"primary wholesale-retail" centers (Minneapolis-St. Paul was classified as a "Metropolis" providing all the goods and services in Figure 2-9 plus others); Missoula and Butte were "secondary wholesale-retail" centers, while eleven communities in Montana provided "complete shopping" (Kalispell, Havre, Glasgow, Helena, Anaconda, Bozeman, Livingston, Lewistown, Miles City, Glendive and Sidney). Another twenty-nine Montana communities provided "partial shopping" or "full convenience."[7]

Empirical applications of the central place model have been made throughout the United States, Europe, and most of the rest of the world. The results are best in predominantly agricultural regions like Montana where the dislocations of uneven resource distribution (like mineral deposits) are minimal. But it is clear that a central place structure underlies every system of cities. The structure may be hard to recognize in some areas where non-agricultural production provides the primary source of economic activity, so the size of cities is distorted substantially from what they would be with only central place functions. If non-central place functions disappear those cities and towns which survive will be those in the central place hierarchy (most of Montana's gold mining towns disappeared, and Butte and Anaconda are both clearly going to be much smaller after full adjustments to the closing of the mine and smelter have been made, but they both appear to have developed some central place functions over time).

Conclusions: Central Places and the Impact of Wheat and Barley on Montana Communities

Now, what does all this discussion of central place theory and a hierarchy of trading areas have to do with the impact of wheat and barley on

different types of Montana communities? To put it bluntly, without the rural agricultural population to serve there would be no central places in Montana.[8] Since virtually all the functions of small communities in the state are central place functions, those communities would not exist. Furthermore, the primary function of most larger towns in the state is to provide goods and services to residents of smaller communities (which exist to serve the agricultural population) and to rural residents. Many of the largest communities in the state do have some non-central place functions so they might exist without agriculture, buy they clearly would be much smaller.

Central places provide goods and services to rural residents and to the population of smaller central places. Thus, expenditures by the agricultural population generate the income that supports most of the towns and cities in an agricultural region. Goods and services flow down the hierarchy while money payments flow up, as implied by the theoretical development above. However, it should also be stressed that the agricultural population (and its income) in the state would probably not exist if it were not for the central place hierarchy. By offering specialized goods and services, the central place system allows specialization in agriculture; without urbanization and its accompanying specialization any rural resident in the area would have to be largely self-sufficient. Furthermore, one set of central place functions not alluded to in the theoretical development is the function of marketing the products of the agricultural sector. The rural population buys goods and services, including production inputs, from urban centers, so money flows up the hierarchy, but agricultural products are also sold in the central places. Therefore, farm products flow up the hierarchy and farm income flows down.

Trading areas can involve centralized sellers such as retailers and dispersed buyers, but they can also involve centralized buyers, like grain elevators, and dispersed sellers. Note that as Montana's central place system developed, every community along the railroads had one or more grain elevator, so the transportation cost farmers had to bear to market their grain was minimized. Of course, with advances in transportation and marketing technology and falling transport rates, grain marketers have been able to take advantage of economies of scale. Terminals now serve larger areas, but without these central place marketing terminals the cost of shipping grain to ultimate markets would be substantially higher, so farm incomes and farm population would be lower. The point is that the system of urban centers and rural population is an integrated system where the well-being and even the existence of each part depends on the well-being and existence of the other parts. Thus, if something happens to affect the income of farmers it will in turn affect the income of residents of small communities whose livelihood depends on farmers. In addition, it will affect the income of residents of large central places whose livelihood depends on those smaller communities and their rural populations.

The impact of a change in the income of farmers on different types of communities in the central place system should be different however. In a <u>relative</u> sense, the small communities which are almost totally dependent on the rural population, should feel the greatest impact. A drop in farm income should put a larger <u>percentage</u> of the population of a small town out of work than of a large city. However, in an absolute sense, the impact of a fall in farm income should be greater for the city. More people will be put out of work in the city than in a small town, even though it is a smaller percentage of the population of the city. This occurs, in part,

because the city is more likely to be supporting non-central place functions (e.g. the air force base in Great Falls, the pulp mill in Missoula, etc.) in addition to the central place goods and services the city supplies to rural and small community populations. Still, the largest communities in the state of Montana should face severe economic setbacks if agriculture income falls significantly since central place functions are clearly a vital component of these communities' economies.

Notes

1. Walter Christaller, Die zentralen Orte in Süddeutshland (Jena: Fischer, 1933), available in a translation by C. Baskin, The Central Places of Southern Germany (Englewood Cliffs, N.J.: Prentice-Hall, 1966); August Lösch, Die räumliche Ordnung de Wirtschaft (Jena: Gustav Fisher, 1944) available in a translation by W.H. Woglom, assisted by W.F. Stolper, The Economics of Location (New Haven, Conn.: Yale University Press, 1954).

2. For recent reviews of this literature see David Segal, Urban Economics (Homewood, Ill.: Richard D. Irwin, 1977); Edgar M. Hoover, An Introduction to Regional Economics, second edition (New York: Alfred A. Knopf, 1975); M.L. Greenhut and Hiroshi Ohta, Theory of Spatial Pricing and Market Areas (Durham, N.C.: Duke University Press, 1975). The discussion which follows is primarily drawn from and paraphrases these three sources. Thus, only material drawn from other sources will be referenced directly in the chapter.

3. Adam Smith, The Wealth of Nations (Middlesex England: Penguin Books, Ltd., 1974; first printed in 1776), pp. 109-111.

4. Lösch, Op Cit.

5. Let p_1 equal the population of the smallest settlement size and r represent the rural population served by that city. Then, the total population served by one of the smallest communities is

$$P_1 = p_1 + r. \tag{1}$$

Lösch assumed each city had a population that was a constant fraction, c, of the population in the area it served, so

$$p_1 = cP_1 = c(p_1 + r) = \frac{rc}{1-c} \tag{2}$$

and

$$P_1 = \frac{p_1}{c} = \frac{r}{1-c}. \tag{3}$$

The population of the smallest community is simply a multiple of the rural population it serves, since its only function is to serve that population. The "urban multiplier" is just $c/(1-c)$.

Now consider higher order central places. Each second order city has a population of p_2. It serves the equivalent of four smaller communities and their rural populations. Therefore,

$$P_2 = P_1 + 3P_1 - p_1 + p_2. \tag{4}$$

This says that the total population served by a city in the second size class, P_2, consists of the total population served by a city of the smallest size class (since it provides all the services available in the smallest community to a rural area identical to that served by one of the smallest towns), plus three additional population sizes of P_1 from the six nearby small communities (half the population served by each of the six smaller towns is served by the second level city as in Figure 2-8). In addition, the city serves its own population, p_2, rather than the population of a smaller town, p_1, so we subtract p_1 and add p_2. Now if P_2 is the same fraction of p_2 as P_1 is of p_1, equation (4) becomes

$$P_2 = 4P_1 - cP_1 + cP_2 \tag{5}$$

or

$$P_2 = \left(\frac{4-c}{1-c}\right)P_1 \tag{6}$$

By similar reasoning

$$P_3 = \left(\frac{4-c}{1-c}\right)P_2 = \left(\frac{4-c}{1-c}\right)^2 P_1, \tag{7}$$

$$P_4 = \left(\frac{4-c}{1-c}\right)P_3 = \left(\frac{4-c}{1-c}\right)^3 P_1, \tag{8}$$

$$P_5 = \left(\frac{4-c}{1-c}\right)P_4 = \left(\frac{4-c}{1-c}\right)^4 P_1, \tag{9}$$

and

$$P_6 = (\frac{4-c}{1-c})P_5 = (\frac{4-c}{1-c})^5 P_1. \qquad (10)$$

In general then,

$$P_n = (\frac{4-c}{1-c})^{n-1} P_1, \; n = 1 \text{ to } 6. \qquad (11)$$

But since P_1 is given by equation (3), equation 11 can be rewritten as

$$P_n = (\frac{4-c}{1-c})^{n-1} (\frac{r}{1-c}) \qquad (12)$$

and by multiplying by $\frac{4-c}{4-c}$ which just equals 1,

$$P_n = (\frac{4-c}{1-c})^n \frac{r}{4-c}. \qquad (13)$$

Finally, given $p_n = cP_n$

$$p_n = (\frac{4-c}{1-c})^n \frac{rc}{1-c}. \qquad (14)$$

In this way, Lösch could predict the population of a city in any size class by knowing the rural population served by the smallest town, or given equation (2), the population of the smallest town.

6. John R. Borchert and R.B. Adams, "Trade Centers and Trade Areas of the Upper Midwest," Upper Midwest Economic Study, The Urban Report No. 3, Minneapolis, September 1963; and John R. Borchert, "The Urbanization of the Upper Midwest, 1930-1960," Urban Report No. 2, Minneapolis, February 1963.

7. Note that while data limitations prevented us from making as fine a breakdown as this 1960 study, the structure of the central place hierarchy we employ does not differ too much from this 1960s study which had much more extensive data (they had sufficient funding so that they were able to survey each community while we were limited to using published data).

8. See footnote 5 where it is demonstrated that the population of any city in the hierarchy is a multiple of rural population. With no rural population there would be no cities.

Chapter 3:
Methodology

Critical to establishing the economic impact of wheat and barley on Montana communities are several prerequisites. First, it is necessary to determine the number of levels to be specified in the spatial hierarchy. Invariably, some mix of personal observation and formal criteria are necessary. Second, the scope of the hierarchy must be specified. Obviously, it would be preferable to include all the population centers of Montana in the analysis and document the actual linkages that occur. Data and financial limitations effectively curtail analysis at that level of detail so it is necessary to develop a general classification scheme. Third, the aggregate impacts of wheat and barley on the Montana economy, as reported in a previous study, must be separated into their component impacts at each level in the hierarchy.[1] A decomposition method must be chosen that reflects the average proportion of impacts for a "typical" community at each level in the hierarchy.

In this study, a general spatial economic network is developed for the state of Montana. This network utilizes counties as the economic units of reference. Counties were chosen as the economic units of analysis due to superior data availability. However, this should not be considered a serious weakness in the generalization of the results to urban units. Montana is a sparsely populated region with dispersed population centers. In many counties, only a single major urban center exists. Therefore, in most cases it is possible to abstract from the town or city level to the county level without significant loss of accuracy.[2]

Levels in the Spatial Hierarchy

It was necessary to develop a formal method that categorized counties in Montana into levels in the spatial hierarchy. Clearly, data on trade flows (both goods and services) between population centers would allow a detailed and accurate representation of the spatial hierarchy. Unfortunately, these data do not exist. An alternative approach, therefore, is to classify population centers according to some criterion and then choose subsets to represent levels in the hierarchy.

Total county income was chosen as the criterion that indicated county size. An alternate approach would define county size according to population. Although this criterion was applied in the early stages of the study, it was determined that this approach had a serious flaw. Economic impact analysis is primarily concerned with the production and trade of goods and services. County income data better reflect the economic size of a community and, hence, its importance in a spatial hierarchy. Therefore, the first step in identifying the levels in Montana's spatial hierarchy was the listing of all counties according to total income.

The second step was the actual choice of levels. Selection of the highest level is quite obvious. Three counties (Yellowstone - Billings; Cascade - Great Falls; and Missoula - Missoula) contain the three major population centers and, hence, the largest total income, in Montana. Determination of other levels in the hierarchy is more difficult. Table 3-1 lists Montana counties according to county income in 1981. After inspection of this table, it is immediately evident that, as one looks down the list to the smaller counties, a clear distinction between the economic sizes of counties is not possible. Therefore, it was necessary to develop a formal technique of selecting hierarchy levels.

Table 3-1: County Income and Hierarchy Levels in Montana, 1981.

County	Major Center	1981 County Income ($ million)	Hierarchy Level
Yellowstone	Billings	952.7	1
Cascade	Great Falls	635.6	1
Missoula	Missoula	600.8	1
Flathead	Kalispell	389.1	2
Lewis & Clark	Helena	359.0	2
Gallatin	Bozeman	314.1	2
Butte-Silver Bow	Butte	284.8	2
Ravalli	Hamilton	144.4	2
Hill	Havre	138.4	2
Lake	Polson	115.0	2
Lincoln	Libby	114.6	2
Richland	Sidney	109.8	2
Custer	Miles City	95.4	2
Dawson	Glendive	94.1	2
Park	Livingston	93.2	2
Anaconda/DeerLodge	Anaconda/DeerLodge	84.9	2
Fergus	Lewistown	79.2	2
Rosebud	Forsyth	77.8	2
Roosevelt	Wolf Point	70.2	2
Valley	Glasgow	69.0	2
Glacier	Cutbank	61.7	3
Big Horn	Hardin	56.7	3
Sanders	Thompson Falls	53.4	3
Carbon	Red Lodge	52.0	3
Beaverhead	Dillon	51.8	3
Jefferson	Whitehall	50.4	3
Pondera	Conrad	49.1	3
Sheridan	Plentywood	45.0	3
Teton	Choteau	45.0	3
Choteau	Fort Benton	43.8	3
Powell	Deer Lodge	41.2	3
Toole	Shelby	41.1	3
Stillwater	Columbus	36.2	3
Blaine	Chinook	35.5	3
Madison	Ennis	32.7	3
Fallon	Baker	29.0	3
Phillips	Malta	28.8	3
Musselshell	Roundup	27.2	3
Mineral	Superior	23.7	3
Broadwater	Townsend	19.4	3
Sweetgrass	Big Timber	19.1	3
Liberty	Chester	18.1	3
Daniels	Scobey	18.0	3
Granite	Philipsburg	16.9	3
Powder River	Broadus	16.4	3

Table 3-1: County Income and Hierarchy Levels in Montana, 1981. (Cont.)

County	Major Center	1981 County Income ($ million)	Hierarchy Level
Judith Basin	Stanford	16.3	3
McCone	Circle	14.1	3
Wheatland	Harlowton	14.1	3
Meagher	White Sulphur Springs	13.1	3
Garfield	Jordan	9.9	3
Prairie	Terry	9.0	3
Wibaux	Wibaux	8.6	3
Carter	Ekalaka	8.3	3
Treasure	Hysham	6.0	3
Golden Valley	Ryegate	4.5	3
Petroleum	Winnett	2.9	3

Source: U.S. Department of Commerce. Current Population Reports, Local Population Estimates: Montana, Bureau of the Census. Series P-2C. No. 82-26-SC. U.S. Government Printing Office. Washington, D.C. September, 1984.

Cluster analysis is an appropriate method of selecting sub-categories from a large group of data. Stated generally, cluster analysis may be defined as an empirical technique that group data into subsets on the basis of similarities across selected attributes. The data are partitioned or subdivided into a hierarchy of homogeneous subgroups. The primary advantage of cluster analysis is that it provides a formal way of classifying data when no prior theoretical rationale can be clearly defined.[3]

The cluster procedure in the Statistical Analysis System (SAS) was used to analyze the total county income data given in Table 3-1. After considerable experimentation with alternative numbers of "clusters," a hierarchical scheme with three levels was chosen. Yellowstone, Cascade, and Missoula counties were classified as Hierarchy One (See Table 3-1). All the counties with 1981 total income between $389.1 and 69.0 million were classified as Hierarchy Two (Flathead through Valley County). Finally, Hierarchy Three was comprised of the remaining counties (less than $69.0 million).

Partitioning the State-wide Impacts

The state-wide impacts of changes in the production of wheat and barley indicate the total economic impacts that ripple throughout the state. However, as was shown in Chapter 2, these impacts not only ripple through various sectors of the economy, but they also ripple geographically through levels of the hierarchy. This leads to the primary research issue of interest here: what is the magnitude of the impacts on the different levels in the hierarchy? A second, and related, question is: What is the impact of changes in the production of agricultural products such as wheat and

barley on the primary urban centers in Montana? This section outlines the procedure used to delineate these hierarchical impacts.

Calculation of Hierarchical Percentages

In order to assess the economic impact on different levels in the hierarchy it was necessary to develop economic profiles for each hierarchical level. The primary data sources were County Profiles, published by the Montana Department of Administration.[4] Detailed county level production data for the agricultural sectors was obtained from Montana Agricultural Statistics. However, incompatible industry definitions, incomplete data, or nonexistent observations created difficulties in some cases (the data were generally quite good in the Agriculture, Retail Trade, and Service sectors). Therefore, upon occasion, it was necessary to utilize judgement in developing a complete data set.

Economic profiles were generated using a cross list of counties and industries. For each county, the number of firms, number of employees, or some measure of industry output were listed by industry. In all cases where data availability permitted, a measure of the actual economic output was utilized. In some cases, however, the only available data were the number of establishments.

The next step involved the calculation of the average output per county of an industry in each hierarchical level. The arithmetic mean was used to indicate average output. Standard deviations were also calculated so that the dispersion around the mean values could be evaluated. Of course, smaller communities did not tend to provide many of the higher order goods and services. These outputs are typically produced in the large trade centers.

The final step involved calculating the economic profile for each hierarchy level. For each hierarchy, all major industry groupings appearing in the Montana Input-Output Model were listed. The percentage of total state output accounted for by the average output of each industry in the hierarchy was entered (hierarchical percentages). Table 3-2 summarizes the hierarchical percentages calculated to show the percentage impact felt in each industry at the one-digit Standard Industrial Clasification (SIC) and for <u>each hierarchical level</u>, with an increase in wheat and barley production. Notice that these percentages refer to the state of Montana, as a whole.

An example should facilitate interpretation of this table. If wheat production increased by $1, there would be an aggregate statewide impact, part of which would occur to the Agricultural sector. The total impact on Agriculture (including the direct, indirect, and induced effects) would be distributed between the hierarchies as follows: 11 percent to Hierarchy One, 38 percent to Hierarchy Two, and 52 percent to Hierarchy Three. A similar interpretation would hold for the other major categories in Table 3-2. In order to view these impacts for a single, average city in each hierarchy level, the aggregate effects must be further divided by the number of cities in that hierarchy level.

Notice, also, that Table 3-2 delineates the hierarchical percentages for sub-industries of the major industry groups. In cases where permitted by data availability, differential percentages were used for each sub-industry. In other cases where data were not available, a constant hierarchical percentage (equal to the aggregate industry level) was used.

Table 3-2: The Hierarchy Percentages for the Entire State of Montana

	Hierarchy One	Hierarchy Two	Hierarchy Three
Agriculture	0.11	0.38	0.52
Agricultural serv., forestry, & fish	0.35	0.41	0.24
Mining	0.16	0.45	0.39
Construction	0.33	0.49	0.17
Manufacturing	0.29	0.51	0.20
Transportation & public utilities	0.34	0.44	0.22
Wholesale	0.40	0.39	0.21
Retail trade	0.32	0.47	0.21
Finance, insurance & real estate	0.43	0.43	0.14
Services	0.39	0.48	0.14
Government	0.36	0.48	0.16

Different Scenarios

The hierarchical impacts of changes in wheat and barley production were calculated under different geographic scenarios. The hierarchical percentages given in Table 3-2 implicitly assume that grain production is evenly distributed across the state. However, the geographic heterogeneity of agricultural production and, hence, the hierarchical impact, in Montana is obvious. The western mountain counties of Montana can be expected to display very different hierarchical impacts than counties located in the eastern part of the state.

Figure 3-1 is a map of Montana's counties. Roughly speaking, counties west of the Continental Divide constitute the western region of the state. These counties (cross hatched on the map) all produced less than one million bushels of wheat, on average, for each year between 1979 and 1982. Largely due to mountainous terrain, counties in the western region produce roughly 2 percent and 8 percent of Montana's wheat and barley, respectively. Therefore, due to this striking difference in agricultural economic structure between the two regions, separate hierarchical percentages were also calculated for each region. Tables 3-3 and 3-4 provide the hierarchical percentages for the eastern and western regions, respectively.

The hierarchical percentages for each region, in addition to percentages for the entire state, were then used to calculate the economic impacts of changes in wheat and barley for communities (i.e., counties) in Montana. The following chapter details these empirical results.

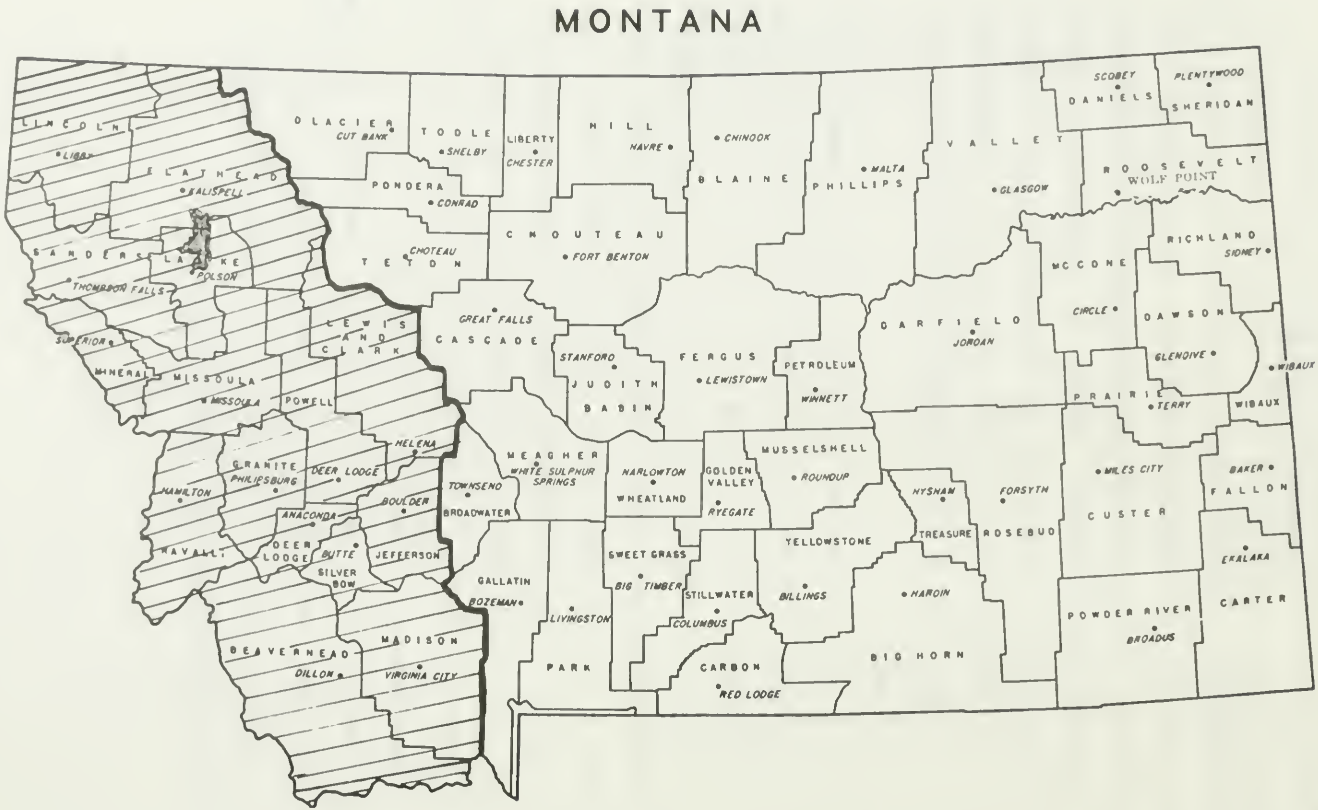


Figure 3-1: Geographic Partition.

Cross-hatched area shows Western Region.

Table 3-3: The Hierarchy Percentages for the Eastern Portion of Montana.

	Hierarchy One	Hierarchy Two	Hierarchy Three
Agriculture	0.12	0.35	0.53
Agricultural serv., forestry, & fish	0.41	0.30	0.29
Mining	0.17	0.45	0.38
Construction	0.38	0.40	0.22
Manufacturing	0.42	0.36	0.22
Transportation & public utilities	0.40	0.33	0.27
Wholesale	0.43	0.31	0.25
Retail trade	0.38	0.36	0.26
Finance, insurance, & real estate	0.52	0.31	0.17
Services	0.47	0.35	0.18
Government	0.46	0.34	0.20

Table 3-4: The Hierarchy Percentages for the Western Portion of Montana.

	Hierarchy One	Hierarchy Two	Hierarchy Three
Agriculture	0.02	0.61	0.37
Agricultural serv., forestry, & fish	0.24	0.59	0.17
Mining	0.09	0.47	0.44
Construction	0.26	0.64	0.10
Manufacturing	0.19	0.63	0.18
Transportation & public utilities	0.25	0.61	0.14
Wholesale	0.31	0.60	0.09
Retail trade	0.24	0.63	0.13
Finance, insurance, & real estate	0.30	0.62	0.08
Services	0.27	0.64	0.09
Government	0.23	0.65	0.12

Notes

1. Readers are encouraged to consult a report by Gary W. Brester, M.D. Faminow, and Bruce L. Benson entitled, The Impact of Wheat and Barley on the Montana Economy: An Input-Output Approach (Department of Agricultural Economics and Economics, Montana State University, June, 1984) for information regarding the initial phase of this study. That report provides a detailed description of the Montana Input-Output Model (MIOM) used in the current analysis.

2. Previous attempts at specifying an economic hierarchy in the northern plains regions have reached similar conclusions. For example, see James A. Chalmers, Eric J. Anderson, Terrance Beckhelm and William Hannigan, "Spatial Interaction in Sparsely Populated Regions: An [sic] Hierarchical Economic Base Approach," (International Regional Science Review 3 (1978): 75-92).

3. Readers interested in a detailed discussion of cluster analysis techniques and theory should consult Maurice Lorr, Cluster Analysis For Social Scientists (Jossey-Bass Publishers, San Francisco, 1983).

4. Department of Administration, Montana County Profiles, The Census and Economic Information Center, Helena, Montana (selected issues).

Chapter 4

Empirical Analysis of the Impact of Wheat and Barley on Montana Cities

The previous chapters have presented the theoretical basis for the observation that changes in economic activity within a region have differential impacts on metropolitan centers. The magnitude of the impact depends upon the cities' central place functions. This chapter presents the empirical results of an increase in wheat and barley production on a single typical city within each of three hierarchies at the one-digit Standard Industrial Classification (SIC) level.

Three methods of disaggregating the economic impacts of a change in wheat and barley production were explored. The following sections discuss the results of two separate methods for projecting these impacts on a typical city, along with a discussion of the problems associated with using each method. The third section of this chapter presents the impacts of increased Montana grain production on a typical city in each hierarchy and employs the superior projection methodology. A final section explores the impacts on the Retail Trade sector at the 2-digit SIC level. Data were available for this sector so that the impacts could be examined using a narrower definition of industries without the loss of confidence in the estimates.

Throughout each of the following sections, a statewide $50 million increase in wheat production is assumed and, subsequently, its effects on a typical city within each hierarchy are estimated. In addition, a $20 million increase in barley production is assumed. Each of these figures is strictly arbitrary and is chosen so as to correspond to the impacts used in

the first phase of this study.[1] It is important to note that while the following discussion analyzes the impacts of increases in production, a decrease in production can easily be assumed by using negative numbers in each of the tables in place of the positive numbers reported here.

Wheat Impacts on the Entire State by City

The first potential method of disaggregation assumed that the impact of wheat production on a typical city was the same regardless of whether the city was in the eastern or the western portion of Montana.[2] The presentation in this section is limited to the impacts of wheat production. The impacts of barley production were analyzed using the same assumptions as wheat production, but in the interest of brevity, only the wheat impacts will be illustrated. Results for barley are presented below for the superior disaggregation technique, however.

The percentage of economic activity in the cities of each of three hierarchies were calculated and multiplied by the statewide impacts of a $50 million increase in wheat production as generated by the Montana Input Output Model (MIOM). These impacts were then divided by the number of cities in each hierarchy. For example, 32% of all retailing activity of Montana is contained in those cities of Hierarchy One, i.e., Billings, Great Falls, and Missoula.[3] Therefore, 32% of the changes in retail activity which result from a $50 million dollar increase in wheat production is estimated to occur in these three cities. To analyze this impact for a typical or average city in Hierarchy One, the impacts on the hierarchy as a whole must be divided by three.

Table 4-1 illustrates the results of this procedure for each of the three hierarchies. The results are presented at the one-digit SIC level.

Table 4-1 The Impacts of a $50 Million Increase in Wheat Production on an Average City by Hierarchy (Impacts divided equally over 100% of Montana, in millions of dollars and actual employment.)

Sector	Hierarchy One			Hierarchy Two			Hierarchy Three		
	Employment	Output	Wages	Employment	Output	Wages	Employment	Output	Wages
Agriculture	33.3	2.018	0.264	20.3	1.230	0.161	13.1	0.795	0.104
Agricultural Serv., forestry and fish	5.9	0.090	0.040	1.2	0.019	0.008	0.3	0.005	0.002
Mining	0.8	0.130	0.023	0.4	0.064	0.011	0.2	0.026	0.005
Construction	4.7	0.149	0.111	1.2	0.039	0.029	0.2	0.006	0.005
Manufacturing	2.4	0.843	0.045	0.7	0.262	0.014	0.1	0.048	0.003
Transportation and public utilities	3.8	0.329	0.083	0.9	0.075	0.019	0.2	0.018	0.004
Wholesale	8.2	0.339	0.144	1.4	0.058	0.025	0.4	0.015	0.006
Retail trade	11.8	0.281	0.128	3.0	0.073	0.033	0.6	0.015	0.007
Finance, insurance, and real estate	14.4	1.639	0.208	2.5	0.289	0.037	0.4	0.044	0.006
Services	15.1	0.473	0.173	3.3	0.103	0.037	0.5	0.014	0.005
Government	0.4	0.033	0.006	0.1	0.008	0.001	0.0	0.001	.000
Totals[a]	100.7	6.326	1.225	35.1	2.220	0.376	16.0	0.989	0.147

[a]Totals may not add due to rounding.

The last row of the table indicates that a 50 million dollar increase in wheat production is estimated to cause 100.7 full-time equivalent jobs to be created in a typical city within Hierarchy One. In addition, an estimation of just over $6.3 million of additional output is generated. The total impacts per city are disaggregated at the one-digit level and are interpreted in an analogous fashion. The simulated impacts for a typical city in Hierarchy Two are lower than those for Hierarchy One. For example, an estimated 35.1 FTE positions are created and $2.2 million of additional output is generated in a typical city in Hierarchy Two. Note, however, that the absolute amount of employment, output, and wages generated by the increase in wheat production is larger within Hierarchy Two than Hierarchy One. This is because a larger number of cities is included within the second hierarchy (i.e., 17 versus 3). Dividing the total impacts for the hierarchy by the number of impacted cities results in a typical city in the higher hierarchy having larger impacts than those in the lower hierarchy. Further note that in terms of income, a typical city in Hierarchy One is about 4.7 times as large as a typical city in two (see Table 3-1), but the estimated employment and output impacts are only roughly 2.8 times as large. This was predicted in Chapter 2. The absolute impact (those in Table 4-1) on a large city is greater than for smaller cities, but the relative impact (relative to the economic size of the cities) is smaller in the largest cities -- the largest cities have more non-central place functions. These basic results carry through all the disaggregation processes discussed, although the actual numerical estimates differ. From Table 3-1, the average city in Hierarchy One has about $730 million in income, while the average city in two has $155 million and the average in three has $28.5 million. Thus, the hypothetical Hierarchy One city described by Table 4-1 is 4.7

times the size of the Hierarchy Two city and 25.6 times the size of the Hierarchy Three city (the hypothetical Hierarchy Two city is 5.4 times the size of the Hierarchy Three community). The output and employment impacts are therefore relatively large in the smallest cities (Hierarchy One's impacts are only 2.8 times two's and 6.3 times three's while Hierarchy Two's impacts are only 2.2 times those for Hierarchy Three).

As mentioned above, this analysis is not extended to barley production impacts because of the assumption that all cities within each hierarchy are impacted by the same magnitude in each sector. That is, eastern cities within Hierarchy One, i.e., Billings and Great Falls, are assumed to be impacted by a change in wheat production in the same manner as is the western city of Hierarchy One, Missoula. However, 98% of all wheat and 92% of all barley is produced in the eastern portion of Montana. Therefore, this methodology probably underestimates the true impacts of wheat and barley production for the eastern cities and overestimates these impacts for the western cities.

Wheat Impacts on the Eastern Portion of Montana by City

A second method of disaggregating the impacts of an increase in wheat production on a city-by-city basis assumes that all of the impacts of such an increase occur in cities within the eastern portion of Montana. After all, the vast majority of wheat is grown in this geographic area. This procedure is an attempt to mitigate the biases which might occur by following the procedures discussed in the previous section.

The percentage of economic activity which occurs in each spatial hierarchy must be re-evaluated. In the previous case the percentages of hierarchical activity were calculated based on data for the entire state,

while these percentages are recalculated here to include only the eastern cities. This is necessary because Eastern Montana cities have a different mix of industries than Western Montana cities. Therefore, the hierarchical percentages specific to Eastern Montana cities were employed for this particular analysis (see Table 3-3 for these figures).

From this point, the analysis parallels the preceding section. Specifically, the total sectoral impacts of a \$50 million increase in wheat production were multiplied by the percentage of economic activity associated with each hierarchy. These figures were then divided by the number of Eastern Montana cities in each hierarchy. Consequently, the entire impacts of an increase in wheat production are allocated to the eastern portion of Montana.

Table 4-2 presents the results of this analysis for a typical city in each hierarchy. The "Totals" row shows that the increased production causes an estimated 174.3 FTE positions to be created in a typical Eastern Montana city within Hierarchy One, i.e., Billings or Great Falls. A smaller number, 50.8, positions are created in a typical city within Hierarchy Two while 21 positions are estimated to be generated in a typical city in Hierarchy Three. Over \$11.2 million of additional output is generated in a city at the Hierarchy One level, while approximately 3.1 and 1.2 million dollars of output is expected to be generated in hierarchies two and three, respectively. The numbers for each of the one-digit SIC industries can be interpreted in a similar fashion.

A comparison of Table 4-2 to Table 4-1 shows that the estimated impacts of an increase in wheat production on a typical city are larger when allocated using the second scenario. Naturally, allocating the same impacts over fewer cities results in larger per city effects. However, these

Table 4-2 The Impacts of a $50 Million Increase in Wheat Production on an Average City by Hierarchy (If all impacts are in the eastern part of Montana, in millions of dollars and actual employment.)

Sector	Hierarchy One			Hierarchy Two			Hierarchy Three		
	Employment	Output	Wages	Employment	Output	Wages	Employment	Output	Wages
Agriculture	54.5	3.303	0.432	31.8	1.927	0.252	16.6	1.006	0.132
Agricultural Serv., forestry and fish	10.4	0.158	0.071	1.5	0.023	0.010	0.5	0.008	0.003
Mining	1.3	0.207	0.036	0.7	0.109	0.019	0.2	0.032	0.006
Construction	8.1	0.258	0.192	1.7	0.054	0.040	0.3	0.010	0.008
Manufacturing	5.1	1.831	0.097	0.9	0.314	0.017	0.2	0.066	0.004
Transportation and public utilities	6.7	0.580	0.147	1.1	0.096	0.024	0.3	0.027	0.007
Wholesale	13.3	0.547	0.232	1.9	0.079	0.033	0.5	0.022	0.009
Retail trade	21.0	0.500	0.227	4.0	0.095	0.043	1.0	0.024	0.011
Finance, insurance, and real estate	26.1	2.974	0.377	3.1	0.355	0.045	0.6	0.067	0.009
Services	27.2	0.855	0.312	4.1	0.127	0.046	0.7	0.023	0.008
Government	0.7	0.064	0.012	0.1	0.009	0.002	0.0	0.002	.000
Totals[a]	174.3	11.278	2.136	50.8	3.188	0.533	21.0	1.286	0.196

[a]Totals may not add due to rounding.

estimates probably exaggerate the impact of wheat and barley on Eastern Montana cities in contrasting fashion to the results in Table 4-1 which exaggerate the impacts on Western Montana cities and underestimate the impacts for communities in the east. It follows that wheat (and barley) production does have some impacts on Western Montana cities, although these impacts are probably of a different magnitude than those for Eastern Montana cities.

Impacts of Wheat Production on the Eastern and Western Portions of Montana by City

Each of the two scenarios presented above probably result in some error in their attempt to estimate the city-by-city impacts of an increase in wheat production. Specifically, the first scenario assumed that Eastern and Western Montana cities have a similar mix of economic functions and are, therefore, impacted in a similar manner with increases in grain production. However, the mountainous western portion of the state produces only a small fraction of the total output of Montana wheat production. The cities in that part of the state have central place functions which are directed at serving the forestry and tourism industries in contrast to the agricultural-based central place functions of cities in the eastern part of the state. Therefore, this first scenario may understate the eastern impacts and overstate the western impacts.

The second scenario attempted to correct the faults of scenario one by assuming that all of the impacts of an increase in wheat production occur in the eastern portion of Montana. This analysis is somewhat limited, since some wheat production actually does occur in Western Montana. Therefore, the impacts of an increase in wheat production are understated for the western portion of Montana and overstated for the eastern portion.

A third scenario was developed which attempts to find a middle ground between each of the previous two methodologies. By assuming that Eastern and Western Montana cities will receive a percentage of the total impacts of an increase in wheat (barley) production equal to the percentage of wheat (barley) produced by each geographic region, the regional differences in hierarchical percentages can be included in the analysis. That is, since 98% of total Montana wheat production is produced in Eastern Montana, the eastern portion of Montana is assumed to be impacted by that same percentage.[4] Two percent of the total impacts of an increase in wheat production must be divided among Western Montana cities. In addition, a separate set of hierarchical percentages were calculated and used for the two separate parts of the State (see Chapter 3). This scenario does not consider the existence of trade between the two regions. However, since both east-to-west and west-to-east trade occurs, the net effect is probably minimal.

The procedure for disaggregating the total impact of a $50 million increase in wheat production is similar to the first two scenarios. For the eastern portion of the state, the total impacts (as calculated by MIOM) are multiplied by 98% and then by the hierarchical percentages for each sector of the eastern part of Montana. These sectoral impacts are then divided by the number of cities in each of the three eastern hierarchies. The result is an estimated impact of a $50 million increase in wheat production for a typical Eastern Montana city.

Table 4-3 presents these results for the one-digit SIC level. The absolute employment, output, and wage impacts are smaller for a typical Eastern Montana city as one moves down the hierarchy. For example, a total of 170.8 FTE positions are expected to be generated in a typical city in Hierarchy One while 49.8 positions are created in a typical city in

Table 4-3 The Impacts of a $50 Million Increase in Wheat Production on an Average Eastern Montana City by Hierarchy. (If 98% of the impacts are in the eastern part of Montana, in millions of dollars and actual employment.)

Sector	Hierarchy One			Hierarchy Two			Hierarchy Three		
	Employment	Output	Wages	Employment	Output	Wages	Employment	Output	Wages
Agriculture	53.4	3.237	0.424	31.2	1.888	0.247	16.3	0.986	0.129
Agricultural Serv., forestry and fish	10.2	0.155	0.070	1.5	0.023	0.010	0.5	0.008	0.003
Mining	1.3	0.203	0.035	0.7	0.107	0.019	0.2	0.031	0.005
Construction	7.9	0.253	0.188	1.7	0.053	0.040	0.3	0.010	0.008
Manufacturing	5.0	1.795	0.095	0.9	0.308	0.016	0.2	0.065	0.003
Transportation and public utilities	6.5	0.569	0.144	1.1	0.094	0.024	0.3	0.026	0.007
Wholesale	13.0	0.536	0.227	1.9	0.077	0.033	0.5	0.022	0.009
Retail trade	20.5	0.490	0.223	3.9	0.093	0.042	1.0	0.023	0.011
Finance, insurance, and real estate	25.5	2.914	0.369	3.0	0.347	0.044	0.6	0.066	0.008
Services	26.7	0.838	0.306	4.0	0.125	0.046	0.7	0.022	0.008
Government	0.7	0.063	0.012	0.1	0.009	0.002	0.0	0.002	.000
Totals[a]	170.8	11.053	2.093	49.8	3.125	0.522	20.6	1.260	0.192

[a] Totals may not add due to rounding.

Hierarchy Two. A typical city in Hierarchy Three generates 20.6 positions. In each of these central places, a substantial portion of the jobs are created in Agriculture, as indicated by the first row of the table. However, a significant number of jobs are created in the Service, Finance, and Retail Trade sectors, particularly in Hierarchy One cities. The total impacts of an increase in wheat production, exclusive of the Agricultural sector, can be calculated by finding the difference between the totals row and the row representing Agriculture. With the exception of Agriculture, the Service, Finance and Retail Trade sectors display the largest increases in output and wages as a result of the simulated increase in wheat production.

Wheat production impacts Western Montana cities differently than eastern cities. Western cities have different central place functions and a different mix of industries. The western cities are more oriented towards forest products and tourism than eastern cities. Therefore, a different set of hierarchical percentages of economic activity are encountered (see Chapter 3).

The city-specific impacts for Western Montana cities were calculated in an analogous fashion to those for Eastern Montana cities with two differences. First, only 2% of the total statewide impacts of a $50 million increase in wheat production (as estimated by MIOM) was allocated to the western hierarchies. This corresponds to the percentage of Montana's total wheat production produced by the region. Second, the hierarchical percentages which describe the proportion of economic activity occurring in each hierarchy of Western Montana were used to estimate the impact of wheat production on each hierarchy. These totals were then divided by the number of cities in each hierarchy to arrive at the impact of wheat production on a typical city of each hierarchy.

Table 4-4 presents the impacts of a statewide $50 million increase in wheat production on a typical city in each of three hierarchies of Western Montana. The bottom row of the table shows that the typical city in each hierarchy displays larger impacts than those in the lower hierarchies. For example, 3.3 FTE positions are created in a typical city in Hierarchy One, 2.6 in Hierarchy Two, and 1.2 in Hierarchy Three. Each of the one-digit SIC sectors displays similar results for employment, output, and wages with the exception of Agriculture. Agriculture displays larger effects on a typical city in Hierarchy Two than in Hierarchy One. This phenomenon is probably explained by noting that Hierarchy One consists of only one city - Missoula. Missoula County has a very small agricultural base. Therefore, a statewide $50 million increase in wheat production has little impact on wheat production in Missoula County since only minor amounts are produced in the region. However, the remaining sectors display increases in employment, output and wages which are larger than the lower hierarchies. Consequently, although little wheat is produced near Missoula, the impact of an increase in wheat production manifests itself in other central place sectors which serve smaller cities in the region.

Overall, the majority of the impacts of a $50 million increase in wheat production occurs in the eastern portion of Montana. This is as expected since 98% of the State's wheat production is grown in that region. Increases or decreases in statewide wheat production will have substantially larger impacts on cities in the eastern region of Montana than those of the western region. Finally, it should be noted that the total impacts on a typical city are probably overstated for two reasons. First, these impacts occur in the entire county in which the typical city is located since county data was used due to the lack of accurate city-specific data. Second, a

Table 4-4 The Impacts of a $50 Million Increase in Wheat Production on an Average Western Montana City by Hierarchy (If 2% of the impacts are in the western part of Montana, in millions of dollars and actual employment.)

Sector	Hierarchy One			Hierarchy Two			Hierarchy Three		
	Employment	Output	Wages	Employment	Output	Wages	Employment	Output	Wages
Agriculture	0.4	0.022	0.003	1.6	0.096	0.013	1.0	0.058	0.008
Agricultural Serv., forestry and fish	0.2	0.004	0.002	0.1	0.001	0.001	0.0	0.000	0.000
Mining	0.0	0.004	0.001	0.0	0.003	0.001	0.0	0.003	0.001
Construction	0.2	0.007	0.005	0.1	0.002	0.002	0.0	0.000	0.000
Manufacturing	0.1	0.033	0.002	0.0	0.016	0.001	0.0	0.004	0.000
Transportation and public utilities	0.2	0.015	0.004	0.1	0.005	0.001	0.0	0.001	0.000
Wholesale	0.4	0.016	0.007	0.1	0.004	0.002	0.0	0.001	0.000
Retail trade	0.5	0.013	0.006	0.2	0.005	0.002	0.0	0.001	0.000
Finance, insurance, and real estate	0.6	0.069	0.009	0.2	0.020	0.003	0.0	0.003	0.000
Services	0.6	0.020	0.007	0.2	0.007	0.002	0.0	0.001	0.000
Government	0.0	0.001	0.000	0.0	0.001	0.000	0.0	0.000	0.000
Totals[a]	3.3	0.203	0.045	2.6	0.160	0.027	1.2	0.073	0.011

[a]Totals may not add due to rounding.

large portion of the output, employment, and wage impacts occur within Agriculture and, therefore, outside of a typical city. Nonetheless, the remaining sectors are indirectly impacted by changes in the Agriculture sector.

Impacts of Barley Production on the Eastern and Western Portions of Montana by City

The simulated city-specific impacts of a $20 million increase in barley production are presented in this section. The disaggregation of the statewide impacts (as calculated by MIOM) for a typical city in each of the three hierarchies for both Eastern and Western Montana cities parallels the procedure used in the previous section. The only difference is that 92% of the increase in barley production is allocated to the eastern hierarchies and 8% is allocated to the western hierarchies. This allocation corresponds to the proportion of Montana's total barley production produced by each region.

Table 4-5 presents the impacts of a $20 million statewide increase in barley production on a typical Eastern Montana city for each of three hierarchies. Once again, the typical city in Hierarchy One displays larger increases in employment, output, and wages than Hierarchy Two. The increases in Hierarchy Two are larger than those in Hierarchy Three. With the exception of Agriculture, employment is most heavily impacted by an increase in barley production in the Service, Retail trade, and Finance sectors. The largest increases in output occur in the Finance and Manufacturing sectors. The largest increase in wages occurs in the Service and Retail trade sectors. In total, estimates of 66.3 additional FTE positions, just over $4 million of output and $800,000 of wages are

Table 4-5 The Impacts of a $20 Million Increase in Barley Production on an Average Eastern Montana City by Hierarchy (If 92% of the impacts are in the eastern part of Montana, in millions of dollars and actual employment.)

Sector	Hierarchy One			Hierarchy Two			Hierarchy Three		
	Employment	Output	Wages	Employment	Output	Wages	Employment	Output	Wages
Agriculture	20.4	1.219	0.182	11.9	0.711	0.106	6.2	0.371	0.056
Agricultural Serv., forestry and fish	3.7	0.056	0.025	0.5	0.008	0.004	0.2	0.003	0.001
Mining	0.6	0.086	0.016	0.3	0.045	0.008	0.1	0.013	0.002
Construction	2.6	0.083	0.061	0.5	0.017	0.013	0.1	0.003	0.002
Manufacturing	2.3	0.743	0.043	0.4	0.127	0.007	0.1	0.027	0.002
Transportation and public utilities	3.1	0.257	0.067	0.5	0.042	0.011	0.1	0.012	0.003
Wholesale	6.4	0.261	0.111	0.9	0.038	0.016	0.3	0.010	0.004
Retail trade	8.5	0.202	0.092	1.6	0.038	0.017	0.4	0.010	0.004
Finance, insurance, and real estate	7.5	0.763	0.113	0.9	0.091	0.013	0.2	0.017	0.003
Services	11.0	0.345	0.126	1.6	0.051	0.019	0.3	0.009	0.003
Government	0.3	0.037	0.005	0.1	0.005	0.001	0.0	0.001	0.000
Totals[a]	66.3	4.052	0.842	19.3	1.176	0.216	7.9	0.477	0.081

[a] Totals may not add due to rounding.

generated in a typical city in Hierarchy One (Billings or Great Falls). The totals row includes the significant impact on the Agriculture sector. For a typical city in Hierarchy Two, 19.3 additional FTE positions, just over $1 million of additional output and $200,000 of additional wages are estimated. Smaller impacts are generated in a typical city in Hierarchy Three.

Table 4-6 presents the impacts of a statewide $20 million increase in barley production for a typical Western Montana city in each of three hierarchies. The table is interpreted in the same fashion as Table 4-5. The estimated impacts are relatively small for all sectors compared to the impacts on a typical Eastern Montana city. This is as expected because only 8% of the state's barley production occurs in the western portion of Montana.

The Impacts of Wheat Production on the Retail Trade Sector of a Typical Eastern Montana City

Table 4-3 presented the impacts of a statewide, $50 million increase in wheat production on a typical Eastern Montana city for each of three hierarchies. These results were presented for the one-digit SIC levels. Data were not available to accurately estimate these findings in more detail for most sectors. However, reasonably accurate data were available to estimate the impacts for the Retail trade sector at the two-digit SIC level. Table 4-7 presents these results. Notice that the first row of Table 4-7 is identical to the eighth row of Table 4-3. The remaining rows of Table 4-7 sum to the total indicated in the first row. That is, the table presents the Retail trade sector in a more disaggregated format. For example, of the estimated 20.5 FTE positions generated in the Retail trade sector of a typical city in Hierarchy One, 5.4 are created by Eating and Drinking

Table 4-6 The Impacts of a $20 Million Increase in Barley Production on an Average Western Montana City by Hierarchy (If 8% of the impacts are in the western part of Montana, in millions of dollars and actual employment.)

Sector	Hierarchy One			Hierarchy Two			Hierarchy Three		
	Employment	Output	Wages	Employment	Output	Wages	Employment	Output	Wages
Agriculture	0.6	0.035	0.005	2.6	0.154	0.023	1.6	0.093	0.014
Agricultural Serv., forestry and fish	0.4	0.006	0.003	0.1	0.002	0.001	0.0	0.001	0.000
Mining	0.1	0.008	0.001	0.0	0.006	0.001	0.0	0.006	0.001
Construction	0.3	0.010	0.007	0.1	0.003	0.003	0.0	0.001	0.000
Manufacturing	0.2	0.058	0.003	0.1	0.028	0.002	0.0	0.008	0.000
Transportation and public utilities	0.3	0.028	0.007	0.1	0.010	0.003	0.0	0.002	0.001
Wholesale	0.8	0.033	0.014	0.2	0.009	0.004	0.0	0.001	0.001
Retail trade	0.9	0.022	0.010	0.3	0.008	0.004	0.1	0.002	0.001
Finance, insurance, and real estate	0.7	0.077	0.011	0.2	0.023	0.003	0.0	0.003	0.000
Services	1.1	0.035	0.013	0.4	0.012	0.004	0.1	0.002	0.001
Government	0.0	0.003	0.000	0.0	0.001	0.000	0.0	0.000	0.000
Totals[a]	5.5	0.314	0.076	4.2	0.256	0.047	1.9	0.118	0.019

[a]Totals may not add due to rounding.

Table 4-7 The Impacts of a $50 Million Increase in Wheat Production on the Retail Sector of an Average Eastern Montana City by Hierarchy.
(If 92% of the impacts are in the eastern part of Montana, in millions of dollars and actual employment.)

Sector	Hierarchy One			Hierarchy Two			Hierarchy Three		
	Employment	Output	Wages	Employment	Output	Wages	Employment	Output	Wages
Retail Trade[a]	20.5	0.490	0.223	3.9	0.093	0.042	1.0	0.023	0.011
Building Materials - Garden Supply	0.8	0.021	0.012	0.2	0.005	0.003	0.1	0.002	0.001
General Merchandise Stores	1.5	0.030	0.017	0.4	0.009	0.005	0.2	0.004	0.002
Food Stores	1.5	0.034	0.019	0.3	0.007	0.004	0.1	0.002	0.001
Auto Dealers - Service Stations	3.2	0.089	0.049	0.7	0.019	0.010	0.2	0.005	0.003
Apparel & Accessories Stores	1.6	0.028	0.015	0.3	0.005	0.003	0.1	0.001	0.001
Furniture & Home Furnishings	1.1	0.027	0.016	0.2	0.004	0.003	0.0	0.001	0.001
Eating & Drinking Places	5.4	0.135	0.038	1.1	0.028	0.008	0.4	0.010	0.003
Miscellaneous Retail	2.7	0.063	0.028	0.6	0.013	0.006	0.1	0.003	0.001

[a]Totals may not add due to rounding.

places, 3.2 by auto dealers, and 2.7 in other Miscellaneous retail establishments. It is interesting to note that the increase in wheat production most heavily impacts Eating and Drinking places, Auto dealers and Service stations, and Miscellaneous retail establishments in each of the hierarchies. Once again, the higher-order hierarchies display larger absolute impacts than the lower-order hierarchies.

Summary

Three approaches at disaggregating the impacts of wheat and barley production in Montana on a city-specific basis were discussed. The first two attempts presented here result in some bias. Therefore, it was decided to pursue a third approach which treats Eastern and Western Montana cities as having different central place systems based on different economic bases (e.g. agriculture vs. forestry). The amount of the increase in wheat and barley production was allocated to each region based upon each region's contribution to Montana's total wheat and barley production.

The smallest absolute impacts occur on the smaller communities. However, on a percentage basis, these impacts have considerable effects on these communities. This result is not surprising in view of the types of businesses that comprise Montana's smaller cities and towns. It is interesting to note the sizable impacts that wheat and barley production has on Montana's larger cities. This is especially evident for the typical Eastern Montana city in Hierarchy One. The inescapable conclusion is that changes in the fortunes of the grain sector (wheat and barley) have a significant impact on major metropolitan centers, like Billings and Great Falls, in Montana.

Notes

1. Interested readers should consult Gary W. Brester, M.D. Faminow, and Bruce L. Benson, The Impact of Wheat and Barley on the Montana Economy: An Input-Output Approach, Department of Agricultural Economics and Economics, Montana State University, June 1984, for a further explanation of these figures.

2. See Chapter 2 for the delineation of Eastern versus Western Montana.

3. Technically, this activity is contained in the counties of Yellowstone, Cascade, and Missoula. As discussed in Chapter 3, the county data were used as proxies for the major cities in each county due to the lack of city-specific data.

4. The annual average wheat production for those counties in the eastern portion of Montana (see note 2) for 1979-1983 are from the Montana Crop and Livestock Reporting Service.

Chapter 5
Project Summary

Phase I of this two-year project, completed during the period of July 1983 to June 1984, involved the development and use of an input-output (I-O) model to estimate the impacts of wheat and barley on the Montana economy. An I-O model is a system of equations that describes the intersectoral flows of goods and services in an economy. Impact multipliers, which estimate the total impact on a regional economy resulting from a change in the output of one or more sectors of that economy, were estimated for wheat and barley production. In addition to describing the structure of Montana's economy, the Montana Input-Output Model was used to simulate the impacts of: (1) an exogenous 10 percent increase in the demand for Montana wheat and barley; (2) government acreage reduction programs (diversion, payment-in-kind); and (3) the establishment of a major Montana beef packing facility on Montana's grain sector. The results of these simulations demonstrated conclusively that wheat and barley production are vital to Montana's economy and significantly impact many sectors through intersectoral linkages. This material is presented in detail in a report submitted to the Montana Wheat Research and Marketing Committee in June, 1984.

Given the statewide impacts of wheat and barley, the second phase of this research project has been to estimate the impacts of wheat and barley production on individual communities. Cluster analysis was employed to disaggregate the statewide impacts into a hierarchical system based on Central Place Theory. This system consists of three levels of cities. County data were used as a proxy for the economic activity of the major city in each county. These hierarchies were further delineated into eastern and western hierarchies in recognition of the relative importance of wheat and barley production on the two diverse regions of Montana.

The largest Montana cities are impacted more heavily in an absolute sense by a change in wheat and barley production. However, in a relative sense, the smaller cities and towns of Montana are more heavily affected by the wheat and barley sectors. That is, while the absolute changes in output, employment and wages which are generated by a change in grain production are greatest in larger cities, these changes are a smaller percentage of the total activity in larger cities than they are in smaller cities. The estimated impacts of wheat and barley production on typical cities presented here may be overstated because of the necessity to use county-specific data as a proxy for the major city in each county. However, this should not affect the relative impacts between each hierarchy.